Conditioning of ionic liquid waste streams in nuclear research applications

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Ionic liquids (ILs) are solvents that consist entirely of ions. In the nuclear field, ILs are considered for reprocessing and partitioning strategies of spent nuclear fuel, both for dissolution of the fuel pellets and for selective separation of actinides by solvent extraction. However, the back-end of the process, namely the waste disposal of radioactively contaminated ILs at the end of their lifetime, is largely overlooked. Moreover, the discarded IL waste stream has to comply with strict conditions to meet the criteria of the local waste treatment companies, which often make straightforward incineration, for example, infeasible. Therefore, new ways of large-scale solidification of radioactively contaminated ILs, that will allow the final conditioned waste package to comply with the strict criteria of the waste repository, have to be developed. In order to decrease the final volume of the solid waste fraction, super-compaction techniques are often applied. Therefore, it is important that no liquid is released when applying high pressures.

In this study a simple and effective solidification method is presented for ILs contaminated by radionuclides. This method can be applied for reasonably large amounts and a large variety of ILs in order to confine them permanently into a matrix that can pass the most stringent liquid release tests. Several porous absorbent materials were tested and compared using two intrinsically different and frequently used ILs, i.e. an ammonium-based IL and an imidazolium-based IL. The presence of free liquid was determined according to the EPA 9096 Liquid Release Test Procedure. However, a much higher pressure was applied in this research to simulate the high-pressure compaction (i.e. pressures up to 70 MPa), of nuclear waste vessels, a technique frequently used by waste treatment operators to minimize the volume of the nuclear waste. An upper limit was found when combining 11.5 mL IL with 100 g fresh Portland cement, using a small quantity of diluent to dissolve the IL for proper dispersion in the cement.